



Calhoun: The NPS Institutional Archive
DSpace Repository

Theses and Dissertations

1. Thesis and Dissertation Collection, all items

1984-09

Economic analysis for ADP

Gardner, Phillip J.; Handrop, Ronald S.; Nichols,
Christopher T.

<http://hdl.handle.net/10945/19280>

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.

Downloaded from NPS Archive: Calhoun



Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

<http://www.nps.edu/library>

COLLETT NOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

ECONOMIC ANALYSIS FOR ADP

by

Phillip J. Gardner

and

Ronald S. Handrop

and

Christopher T. Nichols

September 1984

Thesis Advisor:

Carl R. Jones

Approved for public release; distribution unlimited

T221543

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Economic Analysis for ADP		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis September, 1984
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Ronald S. Handrop Christopher T. Nichols Phillip J. Gardner		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93943		12. REPORT DATE September 1984
		13. NUMBER OF PAGES 68
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/ DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) EA, Economic Analysis, ADP		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This thesis was produced for the Naval Data Automation Command to help increase field analysts' capabilities to produce quality economic analyses. The field analyst is introduced to both concepts and methodology. It is tailored to the field analyst's background. Both economic analysis and budgeting are covered.		

Approved for public release; distribution unlimited.

Economic Analysis
for
ADP
by

Phillip J. Gardner
Lieutenant, United States Navy
B.S., University of Nebraska, 1978

and
Ronald S. Handrop
Lieutenant, United States Navy
B.S., University of West Florida, 1977

and
Christopher T. Nichols
Lieutenant, United States Navy
B.S., United States Naval Academy, 1978

Submitted in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE IN INFORMATION SYSTEMS
from the
NAVAL POSTGRADUATE SCHOOL
September 1984

ABSTRACT

This thesis was produced for the Naval Data Automation Command to help increase field analysts capabilities to produce quality economic analyses. The field analyst is introduced to both concepts and methodology. It is tailored to the field analyst's background. Both economic analysis and budgeting are covered.

TABLE OF CONTENTS

I.	BASIC ECONOMIC ANALYSIS CONCEPT	5
II.	ECONOMIC ANALYSIS	13
	A. INTRODUCTION	14
	B. OBJECTIVES	15
	C. ASSUMPTIONS	15
	D. ALTERNATIVES	16
	E. ESTIMATING COSTS AND BENEFITS	19
	F. STATING THE COMPLETE DECISION PROBLEM ...	21
	G. COMPARING COSTS AND BENEFITS	21
	1. Net Present Value	22
	2. Benefit/Cost Ratio	27
	H. Sensitivity Analysis	30
	1. Two Variable Sensitivity Tests	34
	2. Risk Analysis	36
	I. CONCLUSIONS AND RECOMMENDATION	40
	J. CHARTS AND GRAPHS	40
	K. BUY VERSUS LEASE EXAMPLE	41
III.	FORMATE SUMMARIZED	46
IV.	BUDGETING	50
	LIST OF REFERENCES	62
	APPENDIX A (PPBS)	63
	INITIAL DISTRIBUTION LIST	68

I. BASIC ECONOMIC ANALYSIS CONCEPT

The purpose of this chapter is to provide the reader with a minimal degree of economic analysis background. It is the intent of this chapter to introduce terms and concepts which will be used and expanded upon throughout this manual. The discussion will begin with the concept of economic analysis and then progress to terms used later in the manual.

Economic analysis (EA) is concerned with choice. It is based on the premise that every decision has a number of choices or alternative ways in which to successfully achieve an objective. Specific decision problems will vary, as well as the choices, but essentially, economic analysis is a guideline in a choice situation where there are alternatives with measureable costs and benefits.

Economic analysis is a systematic method of evaluating alternative approaches in a given choice situation. Embedded into the evaluation of alternatives is a set of constraints and criteria by which each alternative is compared. More simply stated then, economic analysis is a method of evaluating alternatives in order to help the decision maker find a solution to the decision problem.

In choosing an alternative, the decision maker must weigh those costs and benefits in terms of tradeoffs: what will not be realized by foregoing a particular alternative. When an alternative is chosen, the benefits and costs of the other alternatives are not realized. So the cost of one alternative may be expressed as those benefits not realized by choosing another alternative.

These views can easily be summed up as follows:

- * EA is a method for evaluating alternatives.
- * EA is only a tool for aiding the decision maker in choice situations, it does not make decisions.
- * EA is an aid to allow decision makers to structure their choices within constraints and provides for a clear criterion in making such choices.

The basic concept of economic analysis can be broken down further into four basic principles:

-CHOICE SITUATION-

1. The analysis is initiated by a need for a decision.

-ALTERNATIVES-

2. The analysis must investigate all reasonable alternative methods of satisfying a given objective (technologically and operationally).

-FUTURE ORIENTED-

3. The analysis must consider both current and future activities and their associated expenditure patterns for all alternatives.

-COST AND BENEFITS COUNT-

4. The analysis must consider the cost of each alternative as well as the benefits of each.

Now that the basic concepts of economic analysis have been presented, the reader should be familiar with some of the terms and their uses within these concepts. The terms discussed here are associated with cost since its role is among the most important.

Costs are normally an essential element of economic analysis since this is the standard by which most alternatives are compared. Costs can be defined as those benefits foregone by choosing a given alternative. The cost product of the economic analysis, however, is very rarely likely to be the same as the budget estimate and less likely to be close to the actual cost. This difference occurs because economic analyses deal with costs in a different way. Economic analysis is used to weigh alternatives via cost and benefit differences, not to arrive at accounting costs. These issues are addressed in more detail in chapters two and three.

Before one can properly understand the evolution of putting together alternatives and comparing costs and benefits, a basic knowledge of general cost categories is required. Generally speaking, EA costs are either recurring or nonrecurring. Nonrecurring costs, as the name implies, are one time costs and are usually associated with the start up phase of a project. Recurring costs occur more or less continuously throughout the life cycle of a project and may be incurred on a daily, monthly, quarterly, semi-annual, or annual basis. Table 1-1 outlines some of the more common costs in each category. (Note: Some of these costs - scrap value, sale of assets, and reutilization - are negative costs. These are costs which are subtracted from the total costs).

Table 1-1

COSTS

NONRECUPRING COSTS

- * research and development
- * investment
- * value of existing assets,
employed
- * scrap value of an asset
(negative cost)
- * sale of an asset
(negative cost)
- * reutilization of an asset
(negative cost)
- * continued use of an asset

RECURRING COSTS

- * civilian personnel
- * military personnel
- * equipment rental/
maintenance
- * space rental/
maintenance
- * materials and supplies
- * utilities
- * communications
- * commercial services
- * overhead costs

Additionally, costs can be classified further as life cycle costs and sunk costs. Life cycle costs are those costs, both recurring and nonrecurring, that are incurred for one particular alternative from the beginning to the end of its life. This normally represents three phases; research and development, investment, and operation. Research and development costs are usually nonrecurring and are independent of units produced or operated. Investment costs are dependent on the number of assets produced or operated and are also a nonrecurring cost. Operating costs are recurring and include support costs, maintenance costs, labor, utilities, etc.

Sunk costs are those costs which have already been incurred or which have been committed irrevocably to a

project. Since such costs are incurred no matter which alternative is chosen, they are not included as part of the life cycle cost analysis. For example, if a given alternative is linked to a research effort undertaken and completed two years prior to the timeframe of the decision, then the cost of that research effort (for instance, \$100,000) must be disregarded in costing out the alternative. It is a sunk cost which in no way affects the future cost of the alternative.

To illustrate these concepts, suppose a manager is faced with the decision problem of which micro computer to buy. At this point, the manager has already identified the decision problem. The manager may place constraints on the decision problem by stating for instance, that the computers must have "X" amount of storage and must fit on a desk top. The decision problem could then be stated as follows:

Minimize lifecycle costs

by choice of a micro system

constrained by:

- * The system must have at least an "X" byte memory.
- * The system must have a "footprint" less than or equal to 60"X 30".

The manager may find two computers which meet the constraints; Micro "A" and micro "B". In addition, he may have decided that the useful life of these computers is five years and the salvage value for each is zero. In other words, he expects at the end of five years to acquire a different system, therefore, the costs are measured for a period of five years. These are the lifecycle costs.

Now the manager must compare the costs of the two computers. The following are the costs associated with each alternative:

COSTS FOR COMPUTER "A":

initial hardware cost: \$2500.00

initial software cost: \$450.00

estimated software costs over next five years: \$1500.00

estimated maintenance costs for the next five years:
\$300.00

estimated utilities costs over the next five years:
\$300.00

estimated labor costs over the next five years:
\$5000.00

total cost: \$10,050.00

COSTS FOR COMPUTER "B":

initial hardware cost: \$2000.00

initial software cost: \$600.00

estimated software cost for next five years: \$ 1800.00

estimated maintenance for the next five years: \$500.00

estimated utilities costs over the next five years:
\$300.00

estimated labor costs over the next five years:
\$5000.00

total costs: \$10,200.00

Some of the costs such as labor and utilities are the same for both computers. They are recurring costs since they occur once a month. They were totaled up above so that the costs could be expressed in life cycle terms. Because they are identical for both alternatives, they need not be included as part of the cost comparison (since they do not affect the decision). As an example of a sunk cost, suppose the manager had paid a consultant to gather this information and perform this study, that cost would not be included in the comparison either since it has already been spent. At this point two key ideas can be summarized:

'-BASE-'

1. The manager must set a base from which the alternatives can be compared.

'-DIFFERENTIAL COSTS-'

2. In making the comparisons of costs for the alternatives, only those costs which are different from one alternative to another are used. Costs which are identical among all alternatives are ignored.

If the manager was asked to find the actual costs for each alternative, then all costs would be included because they are related to the operation of the system. But since only the cost differences are relevant for decision making, labor and utility costs need not be included in the example.

Taking this into account, the differential costs for computer "A" are not \$10,050.00 but \$4,759.00. For computer "B", the differential costs are not \$10,200.00, but \$4,900.00.

The hardware and software costs are nonrecurring costs and may be misleading when considered alone. At first glance, it would appear that computer "B" would be cheaper since the initial costs were \$2,600.00 as opposed to

\$2,950.00. But when the maintenance and projected software costs are included, computer "A" would be the logical choice.

This example could be used in the same manner for any decision problem e.g. buy or lease, automate or status quo. The basic principles are the same for each decision being made and will be addressed in detail in the next chapters.

II. ECONOMIC ANALYSIS

The process used for economic analysis consists of nine key elements:

1. Formulate the basic decision problem.
2. Establish and define a goal or objective.
3. Formulate appropriate assumptions.
4. Search out alternatives for accomplishing the objective.
5. Determine costs (inputs) and benefits (outputs) of each alternative.
6. Formally state the complete decision problem.
7. Compare the costs and benefits of the alternatives.
8. Test the sensitivity of the analysis for major uncertainties.
9. State the resulting recommendations.

All of these key elements are included in the written submission of the economic analysis. The following, which adheres to the format described in Chapter IV, begins the discussion of the EA process--the "how to" portion. It is imperative to understand that the EA process is a process which will likely involve several iterations. So, while each step is described but once, it is likely to be repeated several times.

A. INTRODUCTION

1. Background

Begin by providing the reader with an overview of the existing environment. Identify what problems or opportunities are being studied and include any events which led up to the problem. Finalize with a single sentence formulation of the decision problem to be addressed by the analysis (key element #1). This will effectively direct the scope of the analysis as well.

2. Scope

The scope of the study involves all areas at which the EA is directed. It also specifically excludes those areas not to be considered. Clearly state the scope of the analysis in these terms. This is the focus of the essential decision problem and effectively manages the range of all alternatives.

3. Methodology

While detailed documentation of procedures used for estimating costs and benefits is essential, it is best added as an appendix and a summary of the methodology provided at this point. This allows the reader a brief view of the methodology used without unnecessary detail. The summary should include the time horizon examined, how alternatives were compared (e.g. present value), a statement about the sensitivity analysis, and any findings of previous EA's leading to this report. (e.g. a previous study which found acquisition of a new ADP system to be economically feasible). In general, then, the methodology section will be a summary of the approach taken by the analyst to accomplish the study.

E. OBJECTIVE

The objective of the study should be stated here in terms of a mission or a goal (key element 2). It is crucial that the objective be well defined and without bias. To do this, the analyst must first review what decision is to be made. For example, if the analyst is preparing to meet the first milestone, he/she is dealing with basic system concepts. (The ADP acquisition process is broken down into four major phases called milestones). The decision faced at Milestone I is a basic concept such as improvement of ADP service while reducing costs. At Milestone II of the acquisition cycle the analyst is faced with more specific decisions and the objectives might be stated so as to include what type of ADP equipment should be purchased in order to improve ADP services while reducing costs. The analyst must also ensure that the objective be stated first and then alternatives formulated to meet the objective. Otherwise, the analyst may find himself/herself formulating the objective to fit predetermined alternatives. This is an example of how an analyst might inadvertently form a biased objective.

C. ASSUMPTIONS

In all decision problems, there are accompanying constraints. These are presented here as assumptions (key element #3). The assumptions provide the reader with a means of understanding those aspects of any unknowns or uncertainty the analyst was dealing with when comparing various alternatives. Assumptions serve to reduce the field of study and provide stability in the comparisons. There are three basic rules which should be followed when forming assumptions:

1. Be certain the assumptions are realistic and not mere platitudes or wishful thinking.
2. State assumptions positively, using the word "will". For example, "The ADP system will have an economic life of eight years." "MILCON funds will be available in FY 8X."
3. Ask yourself if your conclusions would be valid if one of the assumptions did not hold true. If the answer is yes, then eliminate that assumption because it is not a requirement that must be met.

D. ALTERNATIVES

As mentioned earlier, the objectives should be formulated immediately following the decision problem. The alternatives are constructed to satisfy the constraints (key element #4). With this in mind, the analyst can eliminate some alternatives by concentrating on only those alternatives which are feasible. In other words, if an alternative does not satisfy the constraints, it is not feasible and should not be considered an alternative. This will still leave the analyst with a number of possible alternatives and theoretically, all alternatives should be studied. This is obviously too time consuming and alternatives should be narrowed down to the feasible alternatives. This includes those necessitated by the constraints imposed on the analysis itself (time and money, in particular). At the same time, the analyst must take care not to prematurely rule out alternatives which may appear to have small benefits but which ultimately may lead to the "optimal" cost-benefit choice.

The analyst should use caution that alternatives do not exceed the stated objectives. This could lead to wasted

effort. For instance, if the objectives are to improve administrative services at lower costs, alternatives that include any aspect of what brand of ADP equipment to buy are wasted effort since this issue is not addressed in the objective. This is a decision that should be addressed in a later EA if in fact, buying new equipment is found feasible. Including such questions as "what equipment should be purchased" also makes it appear that the analyst has already decided that automation via new equipment already outweighs status quo or any other possible alternative.

The point is that the analyst must keep in mind what decisions are being made and avoid bias in addressing those decisions. An example of this occurs when milestone decisions are mixed together. Milestone I deals with the very

TABLE 2-1
MILESTONES

Milestone I		Milestone II
-----		-----
	* status quo	* what type of data
Initial EA		processing installation
=====	* automation	support to use
basic concept		* whether to develop
	* nonautomation	software locally or
		commercially
		* what type of equipment
		to acquire
		* how to acquire the
		equipment
		* verify original
		sensitivity analysis
		and update

basic decisions while milestone II addresses the specifics as to the type of hardware, inhouse/outhouse development of software, etc. As Table 2-1 points out, by including elements of milestone II decisions to alternatives in milestone I, the analyst not only complicates alternatives but wastes a lot of time and effort if automation turns out to be a poor choice in relation to the other alternatives.

To avoid going too far in formulating alternatives, include only those issues which fulfill the following two requirements:

1. Does the alternative satisfy the constraints?
2. Are all elements of the alternative essential in satisfying the constraints?

It may be possible that no alternatives meet the constraints. (Keeping in mind, of course, that this includes the "status quo" alternative. In this case, even the status quo is unacceptable). In such a rare case, the analyst must modify the constraints in order to obtain a selection of alternatives capable of meeting the new constraints.

The alternatives should include all feasible solutions. For example, in a manual versus automation decision, one should consider manual versus semi-automatic versus fully automatic. In a buy versus lease decision, the analyst may want to consider lease to purchase options, or lease then purchase. These decisions are often strongly influenced by Congressional guidance. In other decisions, the ADP analyst may wish to consider the following elements:

- A. Modify the current system by reconfiguring existing ADP resource, hiring additional personnel, etc.

B. Acquiring the capability from a NARDAC or from another government agency through resource sharing.

C. Contracting with non-governmental sources to provide the required capability.

These illustrate the point that alternatives should provide the decision maker with more than simple extreme choices and that in exploring less than the extreme, the analyst may find more feasible alternatives.

Once the alternatives have been identified, they should be presented in detail at this point under the guidelines presented earlier in this chapter. A comprehensive discussion of the techniques and operational characteristics should be depicted for each alternative. The discussion should include a description of the method of operation, the volume of work load, the type of equipment used, and any other factors unique to the system.

One final but important point must be made here about alternatives. Whenever buying a system becomes an alternative, leasing must always be included as another alternative. This decision, buy versus lease must be addressed fully and in great detail. It must be shown, without question, which of these two alternatives is feasible. The issue here deals with present value (discussed later in this chapter) and funds available.

E. ESTIMATING COST AND BENEFITS

Before the analyst can adequately estimate any costs or benefits (key element 5), the time horizon to be studied must first be identified. This time horizon should be stated in terms of the life cycle of all alternatives. Therefore, the analyst should choose that life cycle which

is longest and properly satisfies the project length (choosing the shortest life cycle would automatically eliminate those alternatives with longer life cycles).

Identifying project costs is relatively straightforward, but elimination of equal costs common to each alternative is advisable for larger projects in order to simplify the comparisons. By omitting these costs (for instance, rent for a facility) the task of making comparisons is greatly simplified. If the analyst does omit such costs, they should be identified in the assumptions. This allows the reader to account for total life cycle costs for all alternatives while providing an easy method of comparison.

When accumulating costs over the life cycle, measurements should be in constant dollar values. Inflation factors are ignored when their impact is equal among all alternatives. (For personnel costs, the analyst should refer to the NAVY BILLET COST MODEL for estimates of personnel costs.)

Identifying benefits for each alternative is not as straightforward as cost identification and it is susceptible to a high degree of subjectivity. The real difficulty lies in measuring these benefits in a way to allow a comparison of one benefit to another. Nevertheless, all benefits should be listed even if their measurement may not be possible. This allows the decision maker the opportunity to evaluate the benefits as subjectively as the analyst did.

Still, the analyst must make every effort to formulate benefits in quantitative and measurable terms. In some rare cases, the benefits may have a direct market value and can be measured and compared the same way that costs are. For example, one market valued benefit might be training that other users are willing to pay for. This is not often the case and there are some techniques an analyst may use to help identify and measure benefits:

1. Quantify benefits in terms of dollars by using a comparable operation in the private sector.
2. Express benefits in terms of resources saved (down time, personnel, utilities, etc). Make sure not to include those resources already accounted for by another alternative's cost section such as personnel costs. For example, suppose alternative "A" involves hiring an extra person compared to alternative "B" which does not. If, when comparing costs, the cost of hiring the extra personnel is included in alternative "A", the savings of not hiring that extra person should not be included as a benefit for alternative "B".
3. Express benefits in terms of output (pages/hour, orders/day, operational time/year, etc) and, if possible, value of output.
4. Rank benefits from all alternatives.
5. Assign "points" to benefits according to a weighting scheme. Weighting schemes must be used with care.

F. STATING THE COMPLETE DECISION PROBLEM

Once the analyst has devoted efforts in the previous steps, it is helpful to restate the decision problem based on knowledge gained thus far (key element 6). This is beneficial since the analyst is reminded of the problem at hand. Also, restating the decision problem at this point can lead to new insights as to the constraints.

G. COMPARING COSTS AND BENEFITS

After identifying those costs and benefits each alternative has, the analyst must compare the net present values of

the alternatives. This means arriving at a value comprised of both costs and benefits (key element #7).

Since costs are measured in present dollar values, alternatives which produce a benefit of \$100.00 each could be considered equal despite the fact that the monies are received at different times. To illustrate the present value approach, alternative "A" pays \$100.00 today while alternative "B" pays \$100.00 next year. Alternative "A" would be of more value since the \$100.00 could be put in a bank and earn interest for a year while alternative "B" would not earn any interest income. By the time both alternatives collected the \$100.00, alternative "A" would be worth more money. To evaluate the alternatives on an equal basis, discounts are applied to the \$100.00 received next year so as to allow for comparison on an equal basis. This process is called Net Present Value and is used from a practical perspective according to Navy sources whenever the life cycle exceeds three years. [Ref. 1]

1. Net Present Value

The net present value calculation is the last phase in a cost-benefit analysis. The net present values of the alternatives must be compared against the expected costs or benefits and for sensitivity to various values which are subject to change. The following text will provide the analyst with the necessary tools to help with calculation of Net Present Value.

Essentially, the present value of \$1.00 a year from now is \$.954 using 10 percent as the discount rate. Its value at 10 percent in two years is \$.867 (see table 2-2 for 10 percent value table). OMB has mandated that the discount rate of 10 percent be used. [Ref. 2]

The simplest method for computing net present value is to multiply the costs of a given year times the corresponding discount factor listed in table 2-2. For example, if the cost of a project each year were \$100.00, the net present value of the project over 5 years would be:

$$\begin{aligned}
 &100 \times 1 + 100 \times .954 + 100 \times .867 + \\
 &100 \times .788 + 100 \times .717 = \\
 &100 + 95.4 + 86.7 + 78.8 + 71.7 = \\
 &\$432.60
 \end{aligned}$$

Note that the first \$100.00 is multiplied by one. This means that \$100.00 was paid at the present time for the first year and its value at the present is \$100.00. The

Table 2-2
TEN PERCENT VALUE TABLE

Project Year -----	Present Value of \$1 -----	*	Project Year -----	Present Value of \$1 -----
1	0.954	*	14	0.276
2	0.867	*	15	0.251
3	0.788	*	16	0.228
4	0.717	*	17	0.208
5	0.652	*	18	0.189
6	0.592	*	19	0.172
7	0.538	*	20	0.156
8	0.489	*	21	0.142
9	0.445	*	22	0.129
10	0.405	*	23	0.117
11	0.368	*	24	0.107
12	0.334	*	25	0.097
13	0.304	*		

year one discount factor of 0.954 is applied after one year, or after the majority of the year has elapsed. This method is incorporated in a formula to avoid having to use the tables. Mathematically, the discount factor is $1/(1 + r)^t$, where r is the discount rate and t is the number of years since initiation. So, for a discount rate of 10 percent, the formula becomes $1/(1+.1)^t$. Note Table 2-2 gives mid-year values, i.e. $0.954 = (1.00 + .909)/2$; where $.909 = (1/1.1)$.

With this in mind, the net present value formula can be expressed as follows:

present value of net benefits = sum of the net benefits
(the benefits minus costs)
each year, over the project
life.

In mathematical terms NPV is expressed as follows:

$$\begin{array}{r} (\text{benefits in year1}) - (\text{costs in year1}) \\ \hline (1.1)^1 \\ (\text{benefits in year2}) - (\text{costs in year2}) \\ \hline (1.1)^2 \\ (\text{benefits in year3}) - (\text{costs in year3}) \\ \hline + \dots \text{etc.} \\ (1.1)^3 \end{array}$$

Note: 1.1 is the simplified discount factor for a discount rate of 10 percent $\{ (1 + .1)^t = (1.1)^t \}$.

Example:

	Benefits (\$)	Costs (\$)
	-----	-----
Year 1	120	100
Year 2	130	110
Year 3	140	120

$$\begin{aligned}
 \text{NPV} = & \frac{120-100}{(1.1)^1} + \frac{130-110}{(1.1)^2} + \frac{140-120}{(1.1)^3} = \frac{20}{1.1} + \frac{20}{1.21} + \frac{20}{1.33} = 49.74
 \end{aligned}$$

If all costs and benefits have been entered correctly, then only the projects with positive Net Present Values would be considered.

The net present value concept presented here is only one way to view NPV. Earlier, the discount factor, $(1 + .1)^t$, was applied to the net benefits (benefits minus costs) in each year. Instead of concentrating on net benefits, consider the notion that at every level of resource used there is one level of output. In other words, the analyst thinks in terms of the resources required to produce a specific level of output. If the resources are expressed as costs, then it is the costs required to produce a specific level of output.

This implies that costs can be expressed as a function of output. That is, costs are dependent on the level of output and the detail of multiple inputs that are subsumed in the relationship of output to cost. This is called the cost function and is expressed as follows:

$$\text{cost} = F(\text{output})$$

where $F(.)$ represents the function

If More than one output is expected, the formula is expanded to:

$$\text{cost} = F(Q_1, Q_2, Q_3, \dots, Q_n)$$

where Q_i represents the different outputs.

Using the cost function the same way that net benefits were used earlier, net present value of costs can be expressed as a function of output in the following way:

$$\begin{aligned} & \frac{F(Q_1, Q_2, Q_3, \dots, Q_n) \text{ in year 1}}{(1.1)^1} + \\ & \frac{F(Q_1, Q_2, Q_3, \dots, Q_n) \text{ in year 2}}{(1.1)^2} + \\ & \frac{F(Q_1, Q_2, Q_3, \dots, Q_n) \text{ in year 3}}{(1.1)^3} + \text{etc.} \end{aligned}$$

More simply stated:

$$\frac{\text{costs in year 1}}{(1.1)^1} + \frac{\text{costs in year 2}}{(1.1)^2} + \frac{\text{costs in year 3}}{(1.1)^3} + \text{etc.}$$

Essentially these cost functions can be derived mathematically by using historical data of different output levels to arrive at an equation. Using this technique saves the analyst the trouble of having to research all the cost details of the multiple inputs that is required in the other approach.

Which of the two methods to use in solving a decision problem depends on the nature of costs and benefits associated with each alternative. If all costs and benefits are

expressed in dollars and the benefits vary with each alternative, then the net benefit approach is best. If, on the other hand, benefits are not measurable in dollars and can be fixed at a specific level, then the approach to take is that of minimizing costs given that all the alternatives meet the minimum benefits. When a situation such as this occurs, a benefit/cost ratio for each alternative can be used to develop decision rules that identify the least cost alternative. Benefit/cost ratios are discussed in the next section.

2. Benefit/Cost Ratio

The benefit/cost ratio serves as an economic indicator of efficiency. It relates the outputs expected as a result of undertaking an alternative to the value of the resources expended. In other words, it relates benefits to the costs. This, in turn, numerically illustrates the differences among the alternatives in terms of which gives more benefits per dollar expended (when the benefit level is fixed). There are basically three approaches to understanding BCR and each is described in order of sophistication.

In the first approach, acquiring a single benefit value is the goal. Once this is done for each alternative, the benefit value can be divided by the present value cost to arrive at a benefit/cost ratio. The alternative with the highest benefit/cost ratio is the optimal alternative in this case. This is true since if benefits are fixed, the ratio of benefits to costs (benefits per dollar expended) identifies the the least cost alternative.

There are many methods of acquiring a single benefit value. The easiest method is where benefits are measured in dollars. The benefits are simply added up to provide a single value. For those benefits which do not have dollar

values which can be easily applied, a weighted ranking method might be used. This method deals with several decision factors for which each alternative is given a value (for instance, 0 to 10). Each decision factor is weighted according to the analyst's subjective interpretation of importance.

An example of this method is illustrated by a choice of two computers. Computers A and B are ranked on four decision factors shown in Table 2-3. The table shows the decision factors and the weighting value for each factor, and the assigned value for each computer.

Table 2-3
Benefit Rankings

Decision Factor	Factor weight	Computer A	Computer B
-----	-----	-----	-----
Data Availability	3	9	10
Data Timeliness	2	8	10
Data Accuracy	2	6	9
Utility for	3	9	9
Decision Making			

In this case, the aggregate benefit values for each computer are calculated as follows:

$$\begin{aligned} \text{Computer A: } & (3 \times 9) + (2 \times 8) + (2 \times 6) + (3 \times 9) = \\ & 27 + 16 + 12 + 27 = 82 \end{aligned}$$

$$\begin{aligned} \text{Computer B: } & (3 \times 10) + (2 \times 10) + (2 \times 9) + (3 \times 9) = \\ & 30 + 20 + 18 + 27 = 95 \end{aligned}$$

If the present value costs for Computer A and Computer B are \$120,000 and \$130,000, respectively, the benefit/cost ratios are computed as follows:

$$\text{BCR for Computer A} = 82/120K = .68$$

$$\text{BCR for Computer B} = 95/130K = .73$$

On this basis, Computer B yields a higher return per dollar spent. In the second approach to BCR, a standard required performance level or a minimum benefit level is stated in the decision problem as a constraint. The alternatives are developed and stated so that the constraint is satisfied. The alternative which costs least and meets or exceeds the required performance or minimum benefit level (whichever the case may be) is chosen. The benefit/cost ratio is an appropriate tool to aid the analyst in assigning the alternatives. This is particularly true in the instance when stated performance levels and/or minimum benefits are far exceeded by all of the alternatives. Keeping in mind the structure of the decision problem ('Minimize costs...constrained by...'), the BCR assures the analyst that the least cost per benefit (or performance level) is highlighted. It will also illustrate those alternatives whose excessive performance or benefit levels are not justified by cost (low BCR), and those whose excessive performance/benefit levels are appealing due to low cost (high BCR).

When alternatives are not mutually exclusive, that is, more than one alternative can be used, combinations of alternatives can be used to achieve a minimum level with sometimes lower corresponding costs. This is the third approach to BCR. By computing the BCR for each alternative, it might be possible that no alternative meets the required benefit levels or they far exceed them. In this case, using

a combination of alternatives might bring performance levels up to standards. The same can be done to lower performance levels with corresponding cost savings.

BCR can provide a means of making decisions in other ways. In the previous discussion, the decision problem was to minimize cost given a minimum performance level. BCR can allow choices for decision problems that require the most benefits given a budget constraint (expenditures less than or equal to budget). These decision problems are common when dealing with budgets.

All of these concepts are designed to help the decision maker compare the costs and benefits of alternatives in the same way. Once the decision maker has compared the costs and benefits, critical subjective values must be dealt with in order to evaluate the importance of uncertainties. This is called sensitivity analysis and is discussed next.

H. SENSITIVITY ANALYSIS [Ref. 3]

Sensitivity analysis refers to the method by which the relative magnitude of change in one element of an economic analysis is explored to observe any change in the ranking of alternatives. In effect, it gives the analyst an opportunity to address uncertainties. In sensitivity analysis, one factor or cost element is varied to observe its effect. If that element can be varied over a wide range without affecting the ranking of the alternatives, then that element is said to be insensitive to uncertainties. Some of the elements which should be scrutinized and evaluated are:

1. Cost Estimates. Those major cost elements which when increased or decreased have a significant impact on the present value cost.

2. Length of System Life. The effects of a shorter or longer system life.

3. Volume, Mix or Pattern of Workload. Variations in the estimated volume, mix or pattern of workload which affect the present value of cost.

4. Requirements. The effects of potential changes in requirements resulting from either legislative mandate or changes in functional or organizational structure.

5. Configuration of Equipment or Software. The effects of changes in configuration of equipment, software, data communications and other facilities.

6. Assumptions. The effects of alternate assumptions concerning requirements, operations, facilities and software, etc.

To do a sensitivity analysis, the following steps must be followed in sequence:

1. Choose the elements that when varied, are expected to alter the ranking of alternatives.

2. Vary those elements over a value range while holding the other variables constant. Increases of 10, 25, 50, or even 100 percent should be explored to observe their effect.

3. Determine if these new values change the net present value results or the ranking of the alternatives.

In following these steps, the analyst must first choose the elements which will have the greatest effect on the results of the analysis, that is those key items with the highest percentages of the total cost. An example would be

a project where personnel costs account for 90 percent of the project cost. Varying the smaller percentage items will have little effect overall in a comparison. Each of these dominant items should then be varied over a range of values while holding the other variables constant. If there is considerable uncertainty about the validity of the predicted benefits or costs, the analyst should recalculate the benefit/cost ratios or net present values for the selected alternative values. The analyst should use reasonable bounds for the upper and lower estimates of the item in question. By bracketing the range of values, a better analysis will result. If this analysis reveals that large changes in an item estimate do not alter the outcome of the ranking, then the uncertainty over that one item is unimportant. If the analyst finds that the number of crucial arguments are "large", then judgement will be required in selecting the number of sensitivity analyses to incorporate.

To illustrate this concept, part 1 of Example VIII-1 below provides a basic Present Value Analysis (which indicates that Computer A is the best alternative). Part 2 illustrates the application of sensitivity analysis.

EXAMPLE VIII-1

Part 1

	Computer A -----	Computer B -----
Year One:		
Extra ADPE	\$ 80	0
System Development	100	0
Site Preparation	35	0
Years Two Through Nine		
Personnel	\$ 80/yr	\$120/yr
Other Operating Costs	20/yr	25/yr

Solution

1. Given the above cost data, determine the least costly alternative.

The net present values for Computers A and B (using Table 2-2) are:

$$\begin{aligned} \text{PV(Comp. A)} &= 0.954(\$80 + \$100 + \$35) + 5.088(\$80 + \$20) \\ &= \$205 + \$509 \\ &= \$714 \end{aligned}$$

Note: 5.088 is the sum of the present value factors of years 2 through 9. When one value is constant in an equation like $(Ax2)+(Ax3)+(Ax4)$, the equation can be stated as $(2+3+4)xA$ or simply $9xA$.

$$\begin{aligned} \text{PV(Comp. B)} &= 0 \text{ for the first year} + 5.088(\$120 + \$25) \\ &= \$738 \end{aligned}$$

Thus, computer A costs less.

Part 2 Will the results change if the system development costs are \$120?

$$\begin{aligned} \text{PV(Comp. A)} &= 0.954(\$80 + \$120 + \$35) + 5.088(\$80 + \$20) \\ &= \$224 + \$509 \\ &= \$733 \end{aligned}$$

Since \$733 is less than the cost of computer B, the analysis is not sensitive to a \$20 increase in system development costs.

Will the results change if the system development costs are \$130?

$$\begin{aligned} \text{PV(Comp. A)} &= .954 + (\$80 + \$130 + \$35) + 5.088(\$80 + \$20) \\ &= \$234 + \$509 \\ &= \$743 \end{aligned}$$

In this case costs would be greater for computer A, therefore, the analysis is sensitive to an increase of \$30 in system development costs.

What will be the impact if personnel costs for computer A are increased to \$85 per year?

$$\begin{aligned}PV(\text{Comp. A}) &= 0.954(\$80 + \$100 + \$35) + 5.088(\$85 + \$20) \\&= \$205 + \$534 \\&= \$739\end{aligned}$$

Thus, the analysis is sensitive to this change since the costs for Computer A have exceeded the costs for Computer B.

Example VIII-2

The economic life in the above example is somewhat questionable. Perform a sensitivity analysis to determine what would happen if the economic life was five years instead of eight.

Solution

Based on a five year economic life, the present values of computers A and B are:

$$\begin{aligned}PV(\text{Comp. A}) &= 0.954(\$215) + 3.616(\$100) = \$567 \\PV(\text{Comp. B}) &= 3.616(\$145) = \$524\end{aligned}$$

Computer B is now less costly than computer A. Since the rankings of alternatives has changed, the analysis is sensitive to the shorter economic life.

1. Two Variable Sensitivity Tests

The outcome of an economic analysis is frequently sensitive to more than one input or assumption. Graphical techniques may be used to treat two variables simultaneously. For example, the PV life-cycle cost of computer A in

example VIII-1 can be depicted for simultaneous variations in annual personnel costs and system development costs. If the system development cost is denoted by D and the annual personnel cost by p, total PV life-cycle cost is:

$$PV = 0.954(80 + D + 35) + 5.088(P + 20)$$

Figure 2-1 shows plots of total PV life-cycle costs for various combinations of system development and personnel costs. The personnel cost, P is plotted on the horizontal axis and the development cost, D, is treated as an outside occurring variable. The placement of PV life-cycle cost points readily indicates which combinations of system development and personnel costs are economically preferable to Computer B. The circled point represents the anticipated values, (D = \$100, P = \$80) as used in the original analysis.

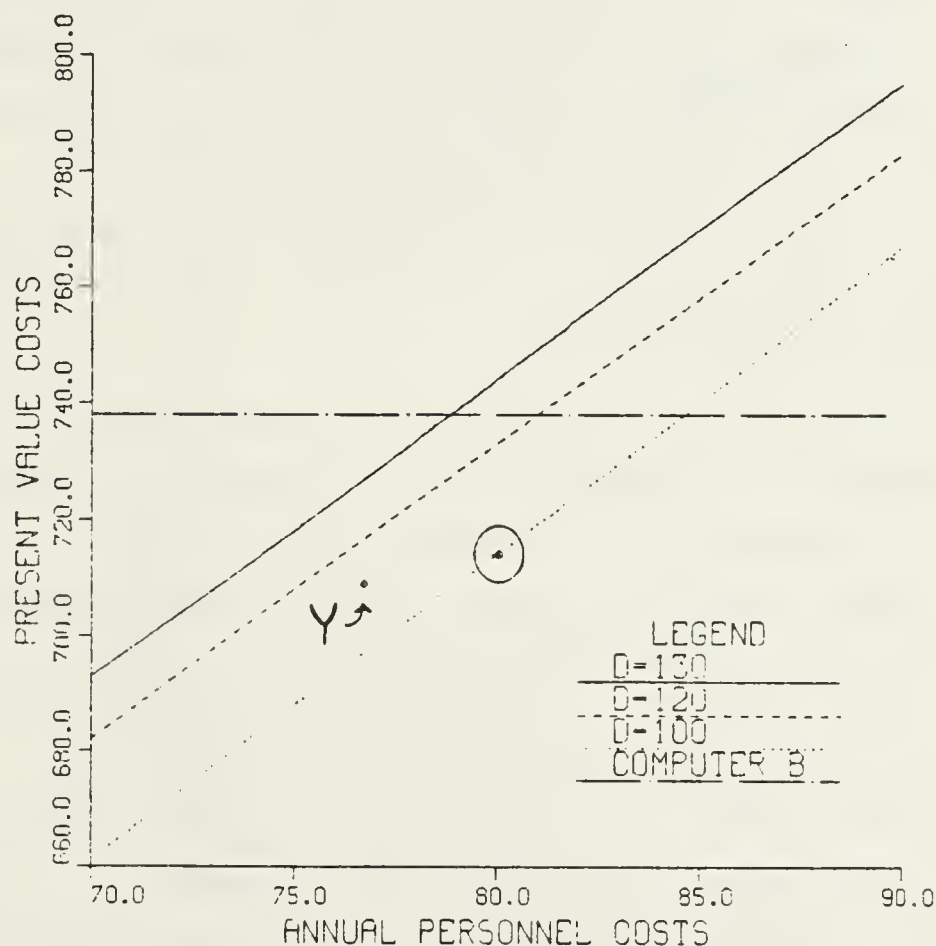


FIGURE 2-1
TWO VARIABLE SENSITIVITY ANALYSIS

Inspection of the graph reveals whether or not the proposed alternative is economically justified. It is justifiable only if the PV point for Computer A lies below Computer B's threshold. The graph also allows the reader to visually interpolate between designated development and personnel costs. For example, if the actual system development cost for Computer A was \$110 and the annual personnel cost was \$77 the PV would be approximately \$708 (see point Y in figure 2-1).

2. Risk Analysis

Risk refers to the variations in outcomes inherent in a decision situations. To a large extent, risk is subjective. Each individual feels differently about risk, and situations will affect each individual differently. A certain individual may be willing to risk \$10 on the toss of a coin for instance, but that same individual may not be willing to risk \$100. By the same token, another individual may not be willing to risk even the \$10 (and another may be willing to risk \$1000). Risk is a part of the Economic Analysis which the analyst is forced to deal with. One way to deal with risk analytically (though the subjective part of risk will always remain) is through the application of probabilities and statistics.

Without getting too technical, the analyst has a number of tools available to assess risk. Since risk deals with variations in outcomes, the logical place to start is to see what range those variations take. The range simply refers to the separation of the maximum and minimum values that are possible. For instance, if based on historical data, six batteries have lifetimes of 3.3, 2.8, 3.4, 3.5, 2.7, and 3.8 hours, then the range is simply the maximum lifetime minus the minimum lifetime, $3.8 - 2.7$, or 1.1 hours. In addition to the range, the average (mean) and the median can be

obtained. The average is the sum of all possible values divided by the total number of values. In this case, $(3.3 + 2.8 + 3.4 + 3.5 + 2.7 + 3.8)/6$, the average is 3.25. The median of a set of data is the value of the middle item (or the mean of the values of the two middle items) when the data are arranged in increasing or decreasing order. Arranging the battery lifetime data in increasing order and determining the median results in the mean of 3.3 and 3.4, or 3.35. The data, by the way, from which range, mean, and are calculated is known as the 'population'.

The mean and the median are helpful, but it is more beneficial to the analyst to know the extent to which a population is dispersed. The range is the first measure of dispersion. However, the standard deviation is probably the best known and most useful measure of dispersion. The standard deviation gives the analyst an indication of how widely the values are dispersed from the mean. After the probability of an event occurring is calculated it can be displayed on a graph such as the ones in figure 2-2.

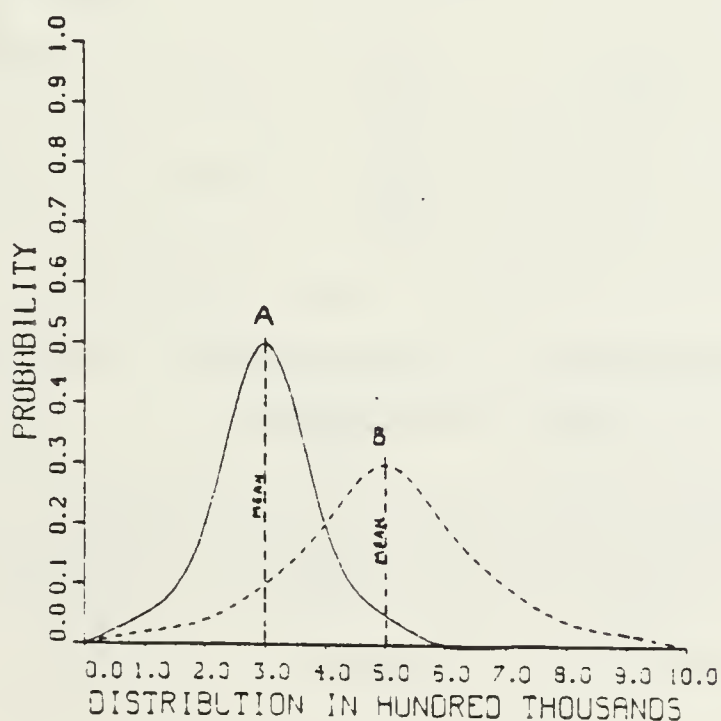


FIGURE 2-2
DISTRIBUTION CURVES

Curve A shows a low standard deviation, and the resulting probability is high that a single value will fall close to the mean. Curve B shows a high standard deviation, and as a result, the probability is relatively low that a value will occur near the mean. Clearly, it is useful to know the mean (where the entire population of data is centered). But one can also see that the standard deviation and probability of any one event (value) in that population occurring can help the analyst better assess risk.

To illustrate the use of the probability of any one event occurring, consider the 'Expected Value Calculation'. Expected value is the sum of all values in a population multiplied by the associated probabilities of each value. Table 2-4 lists the NPV of each event and the associated probability of that event occurring.

Table 2-4
Expected Value Example

	<u>Mean</u>	<u>Probability</u>	<u>Expected Value</u>
	<u>NPV Benefits</u>		<u>(Mean X Probability)</u>
ALT1	\$100,000	.3	\$ 30,000
ALT2	\$300,000	.4	\$160,000
ALT3	\$600,000	.2	\$120,000
ALT4	\$800,000	.1	\$ 80,000

Given this information, alternative 2 has the highest expected value and should be chosen.

Choosing alternatives strictly on the basis of expected value can lead to some costly errors. This means the analyst must use some subjective logic when choosing alternatives in this fashion. For example, suppose two alternatives have the

same costs. Alternative A has a 100 percent chance of yielding \$500,000 while alternative B has a 10 percent chance of producing \$5,500,000 and a 90 percent chance of producing nothing. The expected value for each alternative is shown below:

$$\text{Alternative A} = 1 \times 500,000 = \$500,000$$

$$\text{Alternatives B} = (0 \times .9) + (.1 \times 5,500,000) =$$

$$0 + 5,500,000 = \$550,000$$

Clearly Alternative B has the highest expected value but with only a 10 percent chance of actually realizing \$550,000. There is a 90 percent chance of getting nothing. In this situation, most analysts will choose the less risky option because of the probabilities involved. But not all analysts are alike. Each has a different point at which risk becomes too high for the benefits gained. While most analysts will choose alternative A, some others may still choose alternative B because the benefit of the extra \$50,000 is worth the risk involved to him.

Expected value is only a method of applying probabilities (the probabilities are in and of themselves, a useful tool). The intent here, however, is not to have the analyst sit down with a calculator and calculate these measures. Clearly, more sophisticated methods exist and there are agencies (OP162 for instance) which have the capability to analyze the data. It is important, however, to understand the application of these tools. The analyst must not only consider their application, but also illuminate the risks involved with each alternative to the decision maker.

I. CONCLUSION AND RECOMMENDATION

Once the sensitivity analysis is completed, a summary of the results of the economic analysis should be written to review the outcome of the cost and benefit analysis. This brief summary is the conclusion of the study and merely restates results already found in the analysis. The conclusion should be concise and not include any new or subjective opinions.

Opinions and recommendations should be included in a separate section entitled "RECOMMENDATIONS". At this point, the analyst recommends an alternative to satisfy the decision problem.

J. CHARTS AND GRAPHS

Finally, the use of charts and graphs in an economic analysis will add to the study. Charts and graphs make comparisons easy to see and understand at a glance. They provide a visual means of presenting data in a way that the reader can easily comprehend. The following are areas where charts are recommended: [Ref. 4]

1. Derivation of cost for each major element for each alternative.
2. Display cost elements for each alternative by fiscal year in which they will occur. Separate nonrecurring and recurring costs, further subdividing ADP and functional costs under each category.
3. Display benefits for each alternative.
4. Display computation and results of present value analysis for each alternative.
5. Compare alternatives.
6. Results of sensitivity analysis.

K. BUY VERSUS LEASE

The following is an extremely simplified model illustrating the application of present value analysis to a buy versus lease decision problem. Various elements of the Economic Analysis process and report are therefore not included or only briefly alluded to for the sake of simplicity.

1. Introduction

a. Background

Navy Activity "USN" has determined that a Brand Z word processor is needed to cope with the ever-increasing office workload (as determined by a previous Economic Analysis). The initial decision problem is formulated as follows:

Minimize the lifecycle costs of acquiring Brand Z word processor

constrained by:

Brand Z must be leased or purchased.

b. Scope

The decision to use the Brand Z word processor has already been made. Therefore, no alternatives concerning brand will be addressed. This Economic Analysis is limited to exploring only the method of payment.

c. Methodology

The basic approach of this analysis is to compare present value costs to determine which alternative results in the least cost procurement of the Brand Z word processor.

2. Objective

The objective of this analysis is to examine the most feasible method of acquiring the Brand Z word processor.

3. Assumptions

a. Currently there are only two methods to acquire the word processor from the Brand Z Company. These two methods are purchase and lease.

b. Vendor support in either method of acquisition is the same and no operational or support differences exist.

c. Purchase of Brand Z word processor requires a single full payment.

d. The economic life of the Brand Z word processor is 4 years.

e. Installment contracts (lease) are for a period of 2 years.

4. Alternatives

a. Purchase

Navy Activity "USN" will purchase Brand Z word processor with a single payment of \$8,500.

b. Lease

Navy Activity "USN" will lease Brand Z word processor with monthly payments of \$180 for four years subject to change after the first two years.

5. The Decision Problem

Minimize lifecycle costs

of acquiring Brand Z word processor

Constrained by:

Brand Z must be leased or purchased.

6. Cost Analysis

a. Alternative A (Purchase): a single nonrecurring cost of

\$8,500.

b. Alternative B (Lease): recurring monthly payments of \$180.

7. Benefit Analysis

Since operational supporting costs are the same whether Brand Z is leased or purchased, the only perceivable benefit to lease lies in its flexibility. Should "USN" desire to upgrade its word processor, the costs associated with outright purchase would be saved. Since there are no foreseen changes in the next 4 years, this benefit will not be considered.

8. Comparing Costs (see figure 2-3)

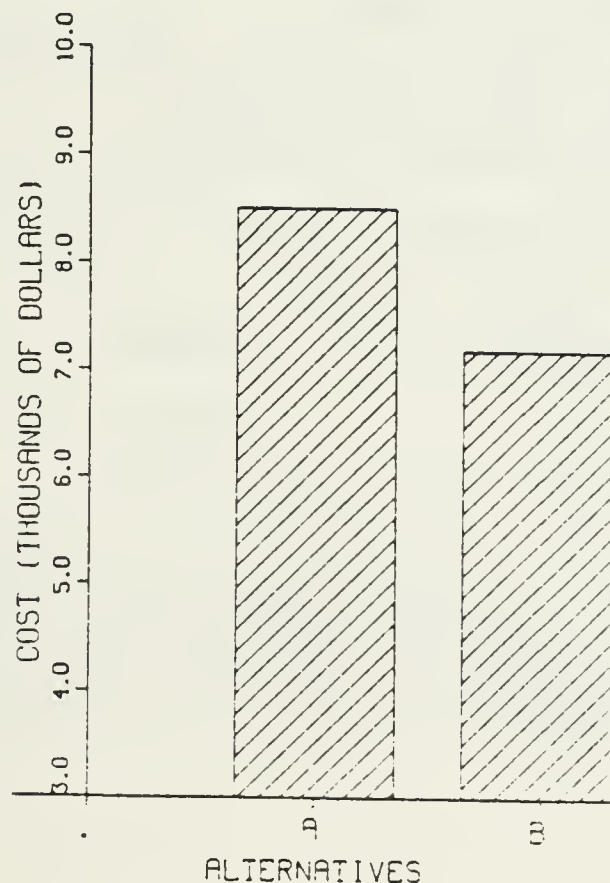


FIGURE 2-3
TOTAL NET PRESENT VALUE COST

Alternative A (Purchase): total net present value cost is \$8,500.

Alternative B (Lease): total net present value cost is \$7,184.16 (as shown in table 2-5)

TABLE 2-5
COST COMPARISON

Project Year	Recurring Costs	Discount Factor	Discounted Costs	Cumulative Costs
1	2160	.954	2060.64	2060.64
2	2160	.867	1872.72	3933.36
3	2160	.788	1702.08	5635.44
4	2160	.717	1548.72	7184.16

9. Sensitivity Analysis

As stated earlier, monthly installments are subject to increase after the first two years. The following are possible installment increases after the first two years and their adjusted net present value costs for Alternative B. (Table 2-6)

Percentage	Cost
10	7509.24
25	7996.85

Since installment increases after the first two years are not expected to exceed 25 percent, Alternative B is still the least cost choice.

TABLE 2-6
SENSITIVITY ANALYSIS

PROJECT YEAR	RECURRING COSTS	DISCOUNT FACTOR	DISCOUNT COSTS	CUMULATIVE COSTS

(10%) 3	2376	.788	1872.29	5805.65
4	2376	.717	1703.59	7509.24
(25%) 3	2700	.788	2127.60	6060.96
4	2700	.717	1935.90	7996.35

10. Conclusions

The results of the economic analysis showed that leasing the Brand Z word processor is the least cost method of acquisition for the intended lifecycle of the system.

11. Recommendations

Based on the results of the economic analysis, leasing Brand Z word processor is recommended over purchase.

NOTES: a. The format and methodology shown above are also applicable to a number of other decision problems (for instance, choice of hardware, site selection, lease versus lease to own, etc.).

b. Cost estimation during the Economic Analysis is often time consuming and inaccurate. To aid the analyst, CNO OP 162 (Economic Analysis Branch) has produced a booklet on cost analysis and maintains several cost models. The office is also available to answer most questions concerning cost estimation.

III. FORMAT SUMMARIZED

The following gives a generalized format for the Economic Analysis.

A. INTRODUCTION

1. Background

Provide the reader with a general overview of the existing environment. Identify specific problems or opportunities being studied and provide an historical account of the major events leading to the problem.

2. Scope

Identify the scope of the study.

3. Methodology

Summarize the procedures for conducting the economic analysis and the techniques used in estimating and computing costs and benefits. Techniques may be detailed in an appendix.

B. OBJECTIVE

State the major objective(s) of the program/project under study. Objectives should be stated in terms of a functional need without implying how they are to be accomplished.

C. ASSUMPTIONS

State all assumptions under which the economic analysis was based. Include the expected economic life and the period to be used in the comparison. Also include any constraints, limitations, or exclusions related to the analysis.

D. ALTERNATIVES

Describe the technical and operational characteristics of the alternatives considered, including the existing system.

1. Current System

The current system represents the alternative which seeks to identify the level of costs and benefits which would accrue without changing the present method of operation. If a current system exists and is considered feasible it will serve as a baseline with which to compare.

2. Proposed System

Describe the overall concept for each of the proposed alternatives. Alternatives which can be shown to be infeasible need not later be quantified but should be addressed.

E. COST ANALYSIS

Identify and describe cost elements for each alternative. Include the computations used to devise total costs and describe in detail the method for developing cost estimates. Use tables, charts, graphs, mathematical models, and other visual aids to assist in the presentation of costs.

F. FORMULATE THE DECISION PROBLEM

Formulate the decision problem so as to identify the decision to be made and the constraints of the problem in the following format:

Minimize lifecycle costs

by choice of

constrained by:

Budget

Other constraints

Maximize lifecycle benefits

by choice of

constrained by:

Benefits greater than or equal to some level B

Other constraints

G. BENEFITS ANALYSIS

Identify and describe all benefits which could be attained by implementing each alternative. Quantify benefits whenever possible. Identify criteria used for measuring benefits and include computations when applicable. Provide a general narrative description of all intangible benefits.

H. COMPARISON OF ALTERNATIVES

Compare alternatives using the Present Value technique. Use visual aids wherever possible.

I. SENSITIVITY ANALYSIS

Describe the approach and assumptions used for conducting the sensitivity analysis. Identify and display the results of analysis for all alternatives for each factor tested. Use tables, graphs, and charts for presenting data, include a narrative to highlight key points in the evaluation.

J. CONCLUSION

Present the conclusion in a clear, concise manner. The conclusion should be brief statements of the most important findings presented in the report. No new material is intro-

duced at this stage. Justifying sentences do not belong in the conclusion. Make your point and stop. Once you arrive at your conclusions, always check to make certain that your discussion substantiates them.

K. RECOMMENDATIONS

The recommendations follow from the conclusions. Recommended actions should be drafted in brief, clear, positive statements. The recommendations must meet the test of suitability, feasibility, and acceptability if they are to provide a complete and workable solution to the problem.

IV. BUDGETING FOR BETTER PLANNING IN ADPE ACQUISITION

A discussion of budgets is important for the analyst for two basic reasons. First, it is essential that the analyst be aware of the differences between economic analysis costs and those estimated for a budget. As stated in the earlier chapter, when costs are identical in comparing alternatives, they need not be included. When developing budget estimates all costs (including inflation rates) must be considered. Budgeting thus is a different decision problem. This obviously makes the budgeted cost of an alternative have a higher cost figure than in the Economic Analysis.

This chapter is intended for the analysts who have little working knowledge of the budgeting system. It is the intent here to provide the analyst a brief glimpse of the system as it is and to set the proper perspective on what can be expected. An expanded explanation of the budgeting process can be found in Appendix A.

To initiate the budgeting process, the analyst must gain a firm grasp of how money is appropriated within the Department of Defense. With this understanding, the analyst is more aware of where money, required by the economic analysis, is going to ultimately come from should the project and the alternative be chosen. The budgeting process is a separate consideration not related to the decision process of the EA. There are two types of appropriations, expense-type appropriations and investment-type appropriations (see Table IV-I). It is likely that the analyst conducting the economic analysis will be more involved with the latter, yet an understanding of both is essential. Expense-type appropriations finance the cost of ongoing operations and are

broken down into two major categories, Operations and Maintenance, and Military Personnel. For instance, in the Navy these funds would be referred to as O&M,N (Operations and Maintenance, Navy) and MPN (Military Personnel, Navy), respectively. Appropriations for the other Armed Forces and the Reserves are similar (O&M,NR-Navy Reserve, for instance). [Ref. 5]

The second type of appropriation is the investment type. As the name implies, rather than financing ongoing operations, investment-type appropriations are generally used to finance projects or items requiring substantial financial investment over a period of time. These funds are also divided into two categories: Procurement and Military

TABLE IV-1
INVENTORY OF APPROPRIATIONS

	<u>NAVY</u>	<u>MARINE CORPS</u>
<u>EXPENSE</u>		
ANNUALLY & INCREMENTALLY FUNDED		
OPERATIONS & -	O&M,N	O&M,MC
MAINTENANCE	O&M,NR	O&M,MCR
MILITARY PAY -	MPN RPN	MPMC,RPMC
TWO YEARS & FULLY FUNDED		
RESEARCH & -	RDTE&E,N	
DEVELOPMENT		
(ALSO INVESTMENT)		
<u>INVESTMENTS</u>		
THREE YEARS & FULLY FUNDED		
PROCUREMENT -	APN OPN WPN	PMC
FIVE YEARS & FULLY FUNDED		
	SCN	
CONSTRUCTION -	MCN MCNR	

construction. Within the procurement subdivision, the services and obligate for specific categories of material such as weapons, aircraft, ships, and most computer systems. As one might expect, the Military Construction Navy (MC,N) is used to construct buildings, erect fences, etc. Found under the procurement subdivision are such categories as OP,N (Other Procurement, Navy), AP,N (Aircraft Procurement, Navy) and so on. Under the MILCON subdivision are MC,N (MILCON, Navy), MC,NR (MILCON, Navy Reserve), etc. Table IV-1 illustrates the divisions of the appropriations.

The Research and Development (R&D) straddles both expense-type and investment-type appropriations. This is because both costs are used in the R&D field. For instance, for R&D, a new weapons system requires a large investment appropriation for the actual R&D and a substantial portion of the expense-type appropriation for the day to day supplies--paper, pens, etc..

The appropriations can also be subdivided in a different manner as to duration and funding. Each appropriation has an Obligational Availability period or duration, during which time the funds are available for use. As one might expect, expense-type appropriations (used for ongoing operations), are incrementally funded for each year and have an annual obligational period. Investment-type appropriations are fully funded ("fully" in the sense that the project is fully appropriated for, such as procurement of x number of aircraft) and are authorized for a certain number of years.

The analyst should be aware of two other sources of funds available for the project. One is maintained by the General Services Administration (GSA) and the other is administered by the Navy Data Automation Command (NAVDAC). The former is the GSA ADP (Automated Data Processing) Fund. It is a

revolving fund administered by GSA which is available for financing the procurement of ADPE (ADP Equipment) by base, purchaser, transfer, or otherwise. NAVDAC administers the Computer Acquisition Program (CAP), essentially a pool of money appropriated by congress for the procurement of computers within the Navy (subject to restrictions).

To put this all in context, suppose an economic analysis is conducted and the most advantageous alternative is to select a new site and construct facilities to have a new computer system (purchase). The threshold for O&M,N funds for instance, is currently \$3,000. Since the new computer system will cost more than \$3,000 (more like \$3,000,000!), the funds must be budgeted from the Investment-type appropriation, Other Procurement, Navy (OP,N). Site construction will obviously come from a MC,N appropriation. The funds for military personnel to support the site will come from Military Personnel,Navy (an expense-type appropriation). Funds for civilian pay will come from the Operations & Maintenance, Navy. Of course, the day to day operations of the center (paper, pencils, etc.) will require money from the Operations & Maintenance, Navy (again, an expense-type appropriation).

Although extremely simplified for illustration, one can see that an economic analysis will involve the analyst in a myriad of areas of which a minimal basic knowledge must be maintained. Thus the analyst can see that the alternatives of the decision problem can greatly influence the budgeting process. It is important to know the origin and the thresholds of the money involved in order to select the truly best alternative.

Once given a project, the analyst will follow the ADPE lifecycle acquisition phases and milestones. This begins

with the Mission Element Needs Statement (MENS) and marks the first budget estimation a analyst will make for the project. The initial and each successive estimation should be included as a budget input to insure future funding. The MENS is submitted as part of the organization's budget estimate in the POM. In the simplest of terms, the POM is a projected spending plan which extends five years ahead into the future for planned actual spending.

When the MENS is submitted as part of the organization POM, two separate items are addressed: 1) requesting permission for or to continue with the project as stated in the MENS, and 2) stating the intent of that organization to spend money sometime in the next five years. The process is repeated each year the project remains alive by updating the POM. A further discussion of this process will reveal the difficulty of providing budget estimates in the MENS and elements which further complicate the budget estimates once the initial POM is accepted.

Recognizing that each level in the chain of command will be submitting budgets and be allocated so much money per year, each level must in turn distribute its funds based on needs. At the field level, the analyst is given guidance from the chain of command for the needs which are felt the most important in the form of the Consolidated Guidance. This provides limits in how much can be budgeted on projects. This emphasizes the need for informal liaison with the chain of command. Unless the analyst's superiors are aware of project costs, they will be unlikely to include those expenditures in the Consolidated Guidance. This is not to say that the project analyst is restricted to the levels stated in the Consolidated Guidance. The analyst can submit a request for additional funds. But approval is more likely to happen with the support of the chain of command.

It is when the analyst submits the MENS that one begins to see just how difficult budgeting can be. The analyst is asked at milestone zero (submission of first MENS) to estimate how much money will be needed to meet the requirements stated in the MENS. How can a analyst estimate the cost of fulfilling a requirement when it has not yet decided how to go about accomplishing that task? For instance, the fulfillment of the MENS might be accomplished by one of many alternatives not yet even formulated. The reality at this stage is to understand the process. If the analyst submits a budget estimation based on any one alternative, then accusations may ensue for prejudging and forming a biased opinion. A solution, in this instance, is to derive the best educated estimate for use in the MENS. This means finding a budget estimate that will cover all alternatives as closely as can be determined without studying alternative costs.

Once the analyst gets past the MENS and progresses to the Systems Decision Paper, better estimates can be derived and the PCM adjusted, because the project is better defined. This means close communication with the chain of command to insure support via consolidated guidance. But the complexity does not end here. The analyst is faced with a project lifecycle which almost always exceeds three years. The analyst is faced at this point with a variety of possible set-backs.

Remembering the division of funds, the analyst may find funds approved for one part of the project and not the other. At one point, the project may be approved and fully funded then suddenly the funds are no longer available because a higher authority withdraws them. At the same time, funding is approved or increased for a project that the analyst feels is less important. These situations do in

fact occur and can leave the analyst frustrated. The more experienced analysts in procurement realize that this is a function of the complex budgeting system of DOD. The analyst must realize that higher authorities are responsible for a myriad of projects and they must prioritize them in the best interest of the country. For example, by necessity, the system has built in levels in the chain of command where funds can be diverted to unforeseen expenditures. These funds are diverted from approved and previously funded projects. When projects already funded do not get approved or fall under budget, extra funds are then made available. Funds can not be used for other projects unless approved by higher authority. This is not to say that if an analyst has a project funded and it is later dropped that these funds may be applied elsewhere. The command's budget must be adjusted accordingly.

Given a general description of the different funds the analyst must deal with, it is often helpful to employ tools to help identify which costs go where. Once the analyst has an understanding for what a project entails, all costs should be identified for the project. This is not an easy task since many costs will vary and some will be nonexistent depending on decisions that will be made in the future. An example may be that of office automation. On one hand, if the economic analysis (EA) proves that procuring a new system is best, the project analyst must include the cost of hardware, software, utilities, maintenance and other such costs associated with buying a new system. On the other hand, the EA may prove the current system best and the costs mentioned above would not apply.

In the early stages of the project, estimates are less accurate than newer ones which are updated yearly in each year's PCM. The analyst cannot be expected to correctly

estimate the exact cost of a project, but a realistic attempt is expected. As the project proceeds to further milestones, the analyst will be expected to refine the estimates.

One way to present a realistic estimate of costs in preparation of a POM is the use of the grid system. The grid system is a method in which individual fund types are identified with individual cost elements. For example, suppose a new office automation system is found to be economically feasible just before the project analyst is required to submit the annual budget estimates. Using the grid system, cost elements may be identified along the left side of the grid and then categorized by the different funds on the top side of the grid as follows:

TABLE IV-2
GRID SYSTEM EXAMPLE

	OE&MN	MPN	OPN	MCON	RDTE	TOTAL
HARDWARE COST			\$X.00	\$Y.00		\$XY.00
SOFTWARE COST	\$X.00				\$Y.00	\$XY.00
PERSONNEL COST	\$X.00	\$Y.00				\$XY.00
MAINTENANCE	\$X.00					\$ X.00
UTILITIES	\$X.00					\$ X.00
TRAINING	\$X.00					\$ X.00
ETC.	\$X.00					\$ X.00

TOTALS	\$X.00	\$Y.00	\$X.00	\$Y.00	\$Y.00	\$ZZ.00

Notice that these costs must be broken down to their appropriate funding categories. This is because different budgeting procedures are used for different funds (Often the

organization will look to the comptroller for help in breaking these costs down into the various categories.)

The key to a successful grid is the detailed cost break down. Too many of the original budget estimates are far off the final costs simply because the analyst failed to identify all costs. During each iteration, the analyst will make more precise estimates of costs that have been identified. These estimates are likely to change with time, as well as with changes to the cost categories. So project analysts can use the grid as both a starting point in the budget process and as an ongoing updating tool for subsequent budget submissions.

Before closing the discussion of budgets, the analyst should be aware of the governing thresholds and approval authorities. To find the approval level for a project enter the ADP Approval Thresholds table IV on the left with the type of procurement involved. Go to the line with the maximum dollar figure for the project and move across to the mark. This gives the column for the approval level. Table III then gives the ADP Approval Authorities. These approval authorities may be delegated to a lower command. This is only a guideline to the approval authorities and thresholds. For precise information on this subject see SECNAV INSTRUCTION 5230.6.

ADF APPROVAL AUTHORITIES

Level 1

Senior ADP Policy Official of the Department of the Navy

level 2

Chief of Naval Operations*

Commandant of the Marine Corps

Director, DON ADP Management**

*COMNAVDAC is delegated CNO/Director, DONADPM

Level 2 approval authority for actions not related to Naval Data Automation Command requirements.

**CNO (Op-942) will exercise Level 2 authority for actions internal to COMNAVDAC.

Level 3

Deputy Comptroller of the Navy

Chief of Naval Research

Chief of Naval Material

Commander in Chief, U.S. Atlantic Fleet

Commander in Chief, U.S. Pacific Fleet

Commander in Chief, U.S. Naval Forces, Europe

Commander, Naval Data Automation Command

Chief of Naval Education and Training

Commander in Chief, Atlantic

Commander in Chief, Pacific

Commander, Naval Military Personnel Command

Level 4

Auditor General of the Navy

Commander, Naval Medical Command

Commander, Military Sealift Command

Commander, Naval Oceanography Command

Commander, Naval Telecommunications Command

Chief of Naval Reserve

Commander, Naval Intelligence Command

Commander, Naval Security Group Command

ADP Approval Thresholds

<u>TYPE APPROVAL</u>	<u>APPROVAL LEVEL</u>			
	Level 1	Level 2	Level 3	Level 4
General Purpose ADPE				
(Sole-source)				
Exceeds \$1M	x			
Up to \$1M		x		
*Up to \$300K			x	
Up to \$50K				x
General Purpose ADPE				
(Competitive)				
Exceeds \$3M	x			
Up to \$3M		x		
Up to \$1M			x	
Up to \$300K				x
ADPE Reutilization				
Leased ADPE	Same as sole source ADPE.			
Owned ADPE	Same as competitive ADPE.			
ADP Services Contracts and Computer Software				
(Initial contract and all options)				
Exceeds \$5M	x			
Up to \$5M		x		
Up to \$1M			x	
Up to \$500K				x
AIS Development and Installation				
Exceeds \$25M	x			
Up to \$25M		x		
Up to \$5M			x	
Up to \$500K				x

ADP APPROVAL THRESHOLDS

(continued)

*\$500K for Exclusively Scientific Actions (ESA). An ESA is acquisition of ADPE which is to be exclusively dedicated to scientific and engineering applications (i.e., design and engineering, simulation, modeling, physical performance or occurrence measurement and analysis, numerical analysis, tracking, trajectory computation, or process control).

LIST OF REFERENCES

1. Naval Data Automation Command Publication 15-7000, Economic Analysis Procedures For ADP, by D.C. Zimmerman, p.2-7, March 1980.
2. Department of Defense Instruction 7041.3, Economic Analysis and Program Evaluation for Resource Management, 18 October 1972.
3. Naval Data Automation Command Publication 15-7000, Economic Analysis Procedures For ADP, by D.C. Zimmerman, Chapter 17, March 1980.
4. Naval Data Automation Command Publication 24.1, Project Management, p. 27, 9 March 1983.
5. Naval Postgraduate School, Comptrollership Course, 1984.

APPENDIX A
THE PLANNING, PROGRAMMING, AND BUDGETING SYSTEM

The Planning, Programming, and Budgeting System (PPBS) is a system designed to assist the Secretary of Defense in making choices about the allocation of scarce resources among a number of competing or possible programs and alternatives to accomplish specific objectives in our national defense. Simply put, the PPBS is a decision-making process for allocating defense resources. Its focus is more on objectives and purposes, and long-term alternative means for achieving them. Also, the PPBS brings together planning and budgeting by means of programming, the process which essentially defines a procedure for distributing the available resources equitably among the competing or possible programs. To summarize, the PPBS can be thought of in strategic terms: based on an anticipated threat, a strategy is developed, requirements of the strategy are then estimated and programs are developed to execute that strategy, and finally, the costs of approved programs are budgeted.

The three phases of the PPBS (Planning, Programming, and Budgeting) each have their own particular set of milestones towards accomplishment. It is important to remember, however, that the road to each milestone is an iterative process. In many cases, the number of iterations can be significantly reduced by the preparation of a proper economic analysis.

The planning phase begins with the issue of the Joint Strategic Planning Document (JSPD) by the Joint Chiefs of Staff. The JSPD provides the advice of the JCS to the President, the National Security Council, and the Secretary

of Defense on not only the military strategy but also the force structure necessary to attain the national security objectives of the United States. Upon review by these agencies, the JSPD is amended to reflect decisions made by the President and/or the Secretary of Defense. The resulting document, the Defense Guidance, provides the guidelines that must be observed by the JCS, the military departments, and defense agencies in the formulation of force structures and the Five Year Defense Plan (FYDP). The Defense Guidance is also used by the Secretary of Defense staff in reviewing proposed programs, particularly with respect to fiscal constraints. Issued by the Secretary of Defense to the services, it marks the end of the Planning phase and the beginning of the Programming phase.

The Programming phase in PPBS is designed to translate the planning of the previous phase into program force structures in terms of time-phased resources requirements, including personnel, monies, and material. This is accomplished by systematic approval procedures that "cost out" force objectives for financial and manpower resources five years into the future.

The critical document during this phase is the Program Objective Memorandum (POM). POM's are prepared by each of the services in response to the Defense Guidance from the Secretary of Defense. The purpose of the POM is to express total program requirements in terms of force structure, manpower, material, and costs, to satisfy all assigned functions and responsibilities during the period covered by the FYDP. The FYDP is the official summary of programs approved by the Secretary of Defense. It specifies force levels in terms of major mission programs and lists total obligational authority by appropriation and manpower. It serves as the controlling internal working mechanism of the Department of

Defense FPBS and periodically records its major outputs--proposed programs and program budget estimates. The POM therefore provides the rationale for alteration to the existing FYDP. Inclusion of a desired system (program) in the current POM is the only way it will be considered by Congress.

The PCM development process consists of many iterations in order that programs (desired and existing) can compete for the existing resources. As such, the POM development phase is divided into three phases: (1) Program Planning Phase, (2) Program Data Base Update Phase, and (3) Final POM Development. Of these three phases, the potentially most important one to those preparing the Economic Analysis is the Final POM Development Phase, often called the "End Game". This phase consists of an iterative process involving program tradeoffs to accommodate necessary constraints. At the end of the process, the presentation of the proposed programs is reviewed by Appropriation Sponsors who advise what changes in packaging by appropriation could be made which would improve the likelihood of survival into the final budget. The Appropriation Sponsors on the CNO staff are:

SCN	OP-03	C&M,N	OP-92
APN	OP-05	MPN	OP-01
OPN	OP-92	O&M,NR	OP-09R
WPN	OP-03	RPN	OP-09R
RDT&E	OP-098		
MILCON	OP-04		

About 30 days after the issue of the Service POM's, the JCS issue the Joint Program Assessment Memorandum (JPAM) which provides the views of the JCS on the respective POM's.

After review, the Secretary of Defense issues the Program Decision Memorandum (PDM) which carries with it final approval of the Service POM's and the milestone ending the Programming Phase and beginning the Budgeting Phase.

For those preparing the Economic Analysis, the level of involvement in the Budgeting Phase is all but nil, yet an understanding is helpful in comprehending the overall process.

The Budget Process is divided into four phases: (1) Executive Formulation and Transmittal, (2) Congressional Action, (3) Budget Execution and Control, and (4) Review and Audit. The Department of the Navy's involvement in the first phase, Executive Formulation and Transmittal, is as described in the previous paragraphs concerning Planning and Programming and will not be reiterated here (the concept of timing will be discussed later). Congressional Action is the next phase whose importance cannot be underestimated. Congress has the power to approve, modify, or disapprove the President's Budget proposals. It can change funding levels, eliminate programs, or even add programs. Congressional review of the budget begins when the President submits his budget in early January. By March 15, each of the standing committees in Congress is required to submit reports on budget estimates to the House and Senate Budget Committees. Also, the Congressional Budget Office is required to submit a fiscal policy report to the two Budget Committees. By May 15, the First Concurrent Resolution is adopted containing government-wide budget targets of receipts, budget authority, and outlays to guide Congress in its subsequent consideration of appropriations and revenue measures. Between this time and September 15, the President submits additional budget amendments and the House and Senate Appropriations Committees prepare spending bills. After

action is completed on the spending bills, Congress adopts (by September 15) the Second Concurrent Resolution containing budget ceilings (and a floor for receipts). Changes recommended by various committees are reported in a reconciliation bill on which Congress must act by 25 September. The budget then becomes effective on 1 October. Congress would be able to pass a supplemental appropriation that would cause budget authority or spending to vary (above or below) the second resolution's total only if it adopted a new budget resolution changing the levels set by the Second Concurrent Resolution. If actions on appropriations are not completed by the beginning of the fiscal year, Congress may enact a Continuing Resolution to provide authority for the affected agencies to continue operations until the regular appropriations are enacted.

TIMING

It is important to understand the timing of events in the PPBS. At any one time, there are three different fiscal year budgets active in varying agencies. The following is provided as an aid to following the process through the Department of Defense to Congressional Enactment of the President's Budget for FY 1987.

Submit JSPD	Aug '84
Submit Defense Guidance	Jan '85
Submit POM	May '85
Submit JPAM	May/Jun '85
Submit PDM	Aug/Sep '85
Submit President's Budget	Jan '86
Budget in force (FY 87)	Oct '86

INITIAL DISTRIBUTION LIST

	No.	Copies
1. Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2	
2. Library, Code 0142 Naval Postgraduate School Monterey, California 93943	2	
3. Naval Data Automation Command Code 11 Washington Navy Yard Washington, D.C. 20374	3	
4. Dr. Carl R. Jones, Code 54Js Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	1	
5. Prof. Dan C. Boger, Code 54Bk Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943	1	
6. Philip J. Gardner 921 Conestoga Drive Columbus, Ohio 43213	1	
7. Ronald S. Handrop 518 Fitzgerald Street Pensacola, Florida 32505	1	
8. Christopher T. Nichols 1424 Lyon Drive Aiken, South Carolina 29801	1	

138375

210211

Thesis
G1882 Gardner
c.1 Economic analysis for
ADP.

8 AUG 89

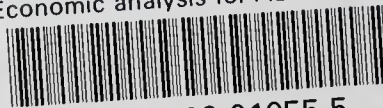
35586

210211

Thesis
G1882 Gardner
c.1 Economic analysis for
ADP.

thesG1882

Economic analysis for ADP /



3 2768 002 01055 5
DUDLEY KNOX LIBRARY